Zitteliana	20	Hagn/Herm-Festschrift	15–24	München, 31. 12. 1993	ISSN 0373-9627

Late Valanginian calcareous nannofossils from central Europe and their biogeographic significance

By
JÖRG MUTTERLOSE*)

With 7 Text-Figures and 1 Plate

KURZFASSUNG

Aus dem tiefen Ober-Valangin (Zone des *Prodichotomites hollwedensis*) von Zentralpolen wird kalkiges Nannoplankton beschrieben. Die Nannofloren zeigen deutliche Beziehungen zu Assoziationen aus NW Deutschland und der Nordsee und haben somit ein boreales Gepräge. Bemerkenswert ist das Fehlen tethyaler Arten, da es bei den gleichzeitig auftretenden Ammoniten starke Einflüsse von Gattungen tethyaler Herkunft gibt. Das Vorkommen borealer Nannofloren in Polen belegt eindrucksvoll die von verschiedenen Autoren (KEMPER, RAWSON & THIEULOY 1982; MUTTERLOSE 1992a) beschriebene weiträumige Transgression im tiefen Ober-Valangin. Im Rahmen dieser Transgression gelangten einerseits tethyale Elemente in das boreale Reich, andererseits konnten boreale Nannofloren zumindest bis Polen vorstoßen. *Micrantholithus speetonensis*, eine Nannofossilart, die bisher nur aus dem Unter-Valangin bekannt war, wird erstmalig aus dem Ober-Valangin abgebildet.

ABSTRACT

Calcareous nannofossils are described from the lower Upper Valanginian (*Prodichotomites hollwedensis* ammonite zone) of Central Poland. The flora shows close similarities to associations found throughout NW Europe and the North Sea, and is thus thought to have Boreal affinities. The absence of Tethyan nannofossils is remarkable, though the ammonites show strong influxes of Tethyan genera. The presence of Boreal nannofloras in Poland clearly indicates that the widespread early Late Valanginian transgression of various authors (KEMPER, RAWSON & THIEULOY 1982; MUTTERLOSE 1992a) was evident here. *Micrantholithus speetonensis*, a nannofossil species, hitherto only known from the Early Valanginian, is documented for the first time from the Late Valanginian.

1. INTRODUCTION AND OBJECTIVES

The marine Lower Cretaceous sediments of central Europe occur at a boundary between two different floral and faunal realms: the Tethys in the south and the Boreal Realm in the north. Within the Boreal Realm continuous Valanginian sections are known from NW Germany only. In NE England (Speeton, Lincolnshire, Norfolk) strata of Valanginian age are extremely condensed and are characterised by several hiatuses (RAWSON et al. 1978).

In Valanginian and Hauterivian times the Carpathian seaway linked the Tethyan and the Boreal Realms via Poland. This marine passage enabled an exchange of marine floras and faunas (MUTTERLOSE 1992a). The migration patterns were mainly controlled by biologic, climatic and palaeoceanographic factors. Valanginian sediments of central Poland thus play a major role in the understanding of migration patterns/directions. Furthermore this area is important for biostratigraphic correlation between Tethyan and Boreal sediments.

*) Prof. Dr. JÖRG MUTTERLOSE, Institut für Geologie, Ruhr Universität Bochum, Universitätsstraße 150, D-44780 Bochum.

In Central Poland, strata of Valanginian age are exposed in the Wawal section which has been studied in detail recently by KUTEK et al. (1989). The Wawal section was measured and sampled by the author in August 1991. Subsequently, the calcareous nannofossil assemblages of this section have been compared to assemblages of the same age from NW Germany. One objective of this study was to observe the nannofloral similarities and differences between Poland and the Tethyan/Boreal Realms. A second objective was to assess the control of migration patterns by climatic variations and/or sea level changes. Finally, the distribution patterns of ammonites and calcareous nannofossils were compared: this clearly has implications for the use of each group in delimiting faunal/floral realms and in inter-realm biostratigraphic correlation.

Samples from the Wawal section in Poland were compared to Valanginian material from NW Germany. The Hollwede and Twiehausen sections described by MUTTERLOSE (1992b) are thought to contain sediments of similar age to those sampled in Poland.

I gratefully acknowledge discussions with E. ERBA (Milano) and A. RUFFELL (Belfast), who critically reviewed the manuscript. Prof. J. KUTEK and Dr. R. MARCINOWSKI (both Warszawa) kindly supplied additional samples from the Wawal section. Financial support is acknowledged by the DEUTSCHE FORSCHUNGSGEMEINSCHAFT (Fi 136/19). The LANDSCHAFTSVERBAND WESTFALEN LIPPE (Münster) supported the field work in NW Germany.

2. METHODS

Simple smear-slide preparations were examined under a Zeiss polarising microscope. The abundance of calcareous nannofossils in the material is variable, but in general low: comprising anywhere from 0% to 10% of the rock. For each sample at least 300 specimens or all specimens in at least 200 fields of view were counted, using a magnification of 1250x. The abundances of each coccolith species were tabulated on the range chart by giving counts for each species/sample. Preservation is indicated as follows: G (good), M (moderate), P (poor). Taxa considered in this study are listed in the appendix. Most bibliographic references for these taxa are given in PERCH-NIELSEN (1985); any not included therein are given in the references. In the captions LM, POL and TL denote light photomicrograph, cross-polarized light and plain transmitted light.

3. SECTIONS STUDIED

Material from three sections of early Late Valanginian age have been examined for their calcareous nannofossil content (Fig. 1).

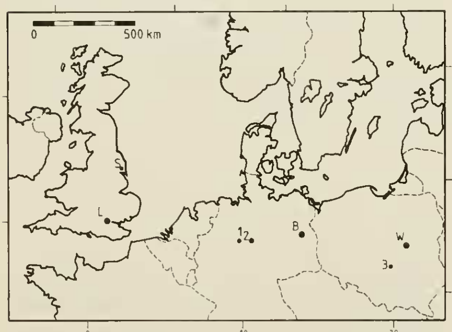


Fig. 1: Location of studied sections. 1 = Hollwede, 2 = Twiehausen, 3 = Wawal. B = Berlin, L = London, S = Speeton, W = Warsawa.

STAGES		Belemnite zones NW-Europe	Biostratigraphic units	Ammonite zones NW-Europe	Ammonite zones Tethys
VALANGINIAN	UPPER	*Acroteuthis acmonoides*	Asterien beds	*Eleniceras paucinodum*	*Neocomites (T.) cullidiscus*
			Arnoldien beds	*Dicostella tuberculata*	
			Dichotomites beds	*Prodichotomoides ivanovi*	*Himantoceras trinodosum*
		Acroteuthis acrei		*Dichotomites bidichotomoides*	
				Dichotomites triptychoides	
				Dichotomites crassus	*Saynoceras verrucosum*
				Prodichotomites polytomus	
				Prodichotomites hollwedensis	
	LOWER	*Acroteuthis kemperi*	*Polyptychites* beds	*Polyptychites sphaeroidalis*	*Thurmanniceras campylotoxus*
				Polyptychites clarkei	
				Polyptychites multicostatus	
				Polyptychites pavlowi	
			Platylenticeras beds	*Platylenticeras involutum*	*Thurmanniceras pertransiens*
				Platylenticeras heteropleurum	
				Platylenticeras robustum	*Th. otopeta*

Fig. 2: Correlation chart of the Tethyan and NW German zonation of the Valanginian. Stippled field shows the interval studied. The zonation has been compiled from numerous sources (see text).

Wawal (Central Poland)

This clay pit, which is still mined, is located east of Wawal, about 10 kilometres southeast of Tomaszow Mazowiecki (Central Poland). Strata dip slightly towards the south and southwest, mining progresses towards the southwest. The old part of the pit, where strata of Early Valanginian age were exposed, has been filled in with gravel. In August 1991 about 6-8 m of clay and siltstone of early Late Valanginian age (*Prodichotomites hollwedensis* ammonite zone; KUTEK et al. 1989) were exposed. The lithology, the biostratigraphy and the position of the samples are shown in Fig. 3. Twelve samples were examined through the section: an additional four samples were supplied by KUTEK and MARCINOWSKI.

Hollwede (NW Germany; TK 25 Lemförde, Nr. 3516, R: 34 65 950, H: 58 07 500)

Mining in this pit, which is located about 80 km west of Hannover, was abandoned some twenty years ago. The section was measured in 1990 by the author. The sediments consist of about 7 m of silty clays, which are of early Late Valanginian age (*Prodichotomites hollwedensis* ammonite zone). Seven samples were studied. MUTTERLOSE (1992b) gives a detailed description of the lithology, the position of the the samples and a list of the macrofauna.

Twiehausen (NW Germany; TK 25 Rahden, Nr. 3517, R: 34 67 080, H: 58 07 400)

Situated about 75 km west of Hannover this pit, which is still mined, exposes about 16 m of rhythmically bedded dark clays and sideritic nodules. The rich ammonite fauna (which includes Tethyan and Boreal genera) shows that the succession belongs to the *Prodichotomites hollwedensis* zone (early Late Valanginian). Only eight samples out of 21 yielded calcareous nannofossils. These samples are derived from the lower part of the section (beds 81–85). For further details see MUTTERLOSE (1992b).

4. BIO- AND LITHOSTRATIGRAPHY

The Valanginian stage in NW Germany comprises 200 m of dark clays. No significant biostratigraphic hiatus has been resolved and the succession is thought to be complete. A detailed zonation exists for ammonites (e. g. KEMPER 1978, RAWSON 1983), belemnites (MUTTERLOSE 1990), foraminifera (BARTENSTEIN & BETTENSTAEDT 1962) and nannofossils (MUTTERLOSE 1992c). A comprehensive overview has been given recently by MUTTERLOSE (1992a). Based on the ammonite genera *Platylenticeras* and *Polyptychites* the Lower Valanginian can be subdivided into the lower *Platylenticeras* beds and the upper *Polyptychites* beds. The Late Valanginian is characterized by the onset of the boreal ammonite genera *Prodichotomites* and *Dichotomites*. The early Late Valanginian *Prodichotomites hollwedensis* ammonite zone shows strong influxes of Tethyan ammonites (KEMPER et al. 1981).

The Lower Valanginian in Central Poland is represented by the *Platylenticeras* beds and the *Polyptychites* beds. The presence of these ammonite genera indicate strong links with NW Europe. The Late Valanginian comprises 30–50 m of clays and siltstones (MAREK & RACZYNSKA 1979, RACZYNSKA 1979, MAREK 1983). Whilst boreal ammonite genera (*Dichotomites*, *Prodichotomites*) are common, Tethyan genera (*Saynoceras*, *Leopoldia*, *Astieria*, *Neocomites*, *Bochianites*) occur at certain levels. KUTEK et al. (1989), who described the ammonite sequence of the Wawal section, clearly demonstrated the mass occurrence of Tethyan ammonite genera (*Saynoceras*, *Valanginites*, *Olcostephanus*, *Sarasinella*, *Neocomites*, *Neohoploceras*, *Karakaschiceras*, *Bochianites*) in the *Prodichotomites hollwedensis* ammonite zone. These ammonite genera are associated with boreal *Prodichotomites*.

5. DISTRIBUTION OF FLORAS

5.1 WAWAL (POLAND)

Twelve samples from the early Late Valanginian of the Wawal section of Central Poland have been examined. Fig. 4 gives the ranges of the species encountered. Both diversity and abundance of calcareous nannofossils are low, though the calcium carbonate contents varies between 5–15%. The majority of samples showed only moderate preservation, this being especially true for the central part of the section. In addition, poor preservation was found to correspond to impoverished assemblages. Apart from samples 99/4 and 99/5 more than 200 fields of view have been examined without counting more 200 specimens. A higher diversity, which correlates with a higher abundance, has been observed in samples 99/4 and 99/5 only. It is remarkable that the calcium carbonate content (8.5%) of these samples is only average. Shells of bivalves, which are scattered throughout the section, mainly contribute to the calcium carbonate content.

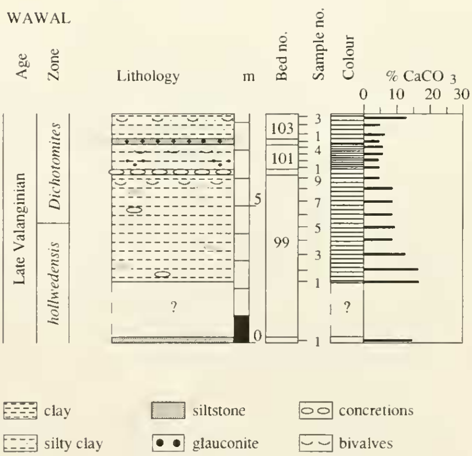


Fig. 3: Bio- and lithostratigraphy of the Wawal section (Central Poland). Biozonation after KUTEK et al. (1989). The question mark indicates an interval of about two metres which was not exposed in 1991.

Age	Late Valanginian											
Ammonite Zone (WAWAL)	hollwedensis					Dichotomites						
Sample no.	98/1	99/1	99/3	99/4	99/5	99/7	99/9	101/1	101/3	102/1	103/1	103/3
Fields of view	200	200	200	53	200	200	200	200	200	200	200	200
Number of species	4	11	6	28	24	2	5	6	12	2	11	11
Individuals	30	26	193	300	303	41	33	48	28	4	32	54
Preservation	M	M	P	G	G	P	P	P	P	P	M	M
Biscutum constans	1	.	1	26	6	.	.	1	1	.	2	1
Cyclagelosphaera margerelii	1	1	6	15	3	1	2	2	1	.	1	5
Watznaueria barnesae	27	16	180	118	190	40	28	41	13	3	16	37
Watznaueria ovata	1	.	3	5	2	.	.	.	.	.	1	.
Axopodorhabdus dietzmanii	.	1	.	4	4	.	.	.	.	.	.	.
Crucibiscutum salebrosum	.	1	.	1	1	.	.	.	.	.	.	.
Diazomatolithus lehmanii	.	1	.	20	3	.	1	.	3	.	1	1
Lithraphidites carniolensis	.	1	1	16	3	.	.	.	1	.	.	1
Micrantholithus obtusus	.	1	.	4	2	.	.	.	.	.	.	4
Micrantholithus speetonensis	.	1	.	.	.	.	.	.	.	.	.	.
Rotelapillus laffittei	.	1	.	7	7	.	.	.	.	.	.	1
Vekshinella stradneri ssp. 1	.	1	2	11	3	.	.	1	1	.	6	1
Zygodiscus diplogrammus	.	1	.	17	33	.	.	.	.	.	.	.
Discorhabdus rotatorius	.	.	.	1	1	.	.	.	.	.	.	.
Cretarhabdus crenulatus	.	.	.	1	4	.	.	.	1	.	.	.
Cretarhabdus striatus	.	.	.	1	.	.	.	.	.	.	.	.
Cretarhabdus sp.	.	.	.	3	1	.	.	1	3	.	.	1
Diadorhombus rectus	.	.	.	1	.	.	.	.	.	.	.	.
Grantarhabdus meddii	.	.	.	2	.	.	.	.	.	.	.	.
Microstaurus chiastius	.	.	.	1	.	.	.	.	.	.	.	.
Manivitella pemmatoidea	.	.	.	1	.	.	.	.	.	.	.	.
Nannoconus sp.	.	.	.	1	.	.	.	.	.	.	.	.
Rhagodiscus asper	.	.	.	15	12	.	1	.	1	.	1	.
Sollasites horticus	.	.	.	1	1	.	.	.	.	.	.	.
Speetonia colligata	.	.	.	1	.	.	1	1	.	.	.	.
Tegumentum striatum	.	.	.	2	1	.	.	.	1	.	1	.
Vekshinella quadriarculla	.	.	.	2	1	.	.	.	.	.	.	.
Vekshinella stradneri ssp. 2	.	.	.	1	.	.	.	.	.	.	.	.
Zygodiscus erectus	.	.	.	22	7	.	.	.	.	.	1	1
Cretarhabdus conicus	.	.	.	.	2	.	.	1	.	.	1	.
Nannoconus elongatus	.	.	.	.	1	.	.	.	.	.	.	1
Vekshinella stradneri ssp. 3	.	.	.	.	11	.	.	.	.	1	.	.
Vekshinella stradneri ssp. 4	.	.	.	.	4	.	.	.	.	.	.	.
Cretarhabdus angustiforatus	.	.	.	.	.	.	.	.	1	.	1	.
Watznaueria britannica	.	.	.	.	.	.	.	.	1	.	.	.
Sample no.	98/1	99/1	99/3	99/4	99/5	99/7	99/9	101/1	101/3	102/1	103/1	103/3
% $CaCO_3$	14.2	15.8	11.6	8.4	8.5	8.1	4.8	4.9	5.8	5	5.5	13
Lithology												
Age	Late Valanginian											

Fig. 4: Distribution of nannofossils in the Wawal section, Central Poland. Preservation: G = good, M = moderate, P = poor. For the exact position of the samples and the explanation of the lithology compare Fig. 3.

Age	Late Valanginian								
Ammonite Zone (HOLLWEDE)	hollwedensis								
Sample no.	95/1	95/2	97/1	97/2	99/1	99/2	99/3	101/1	103/1
Fields of view	200	200	200	53	72	200	200	75	200
Number of species	17	15	3	27	24	15	4	25	8
Individuals	133	110	12	297	308	287	21	332	35
Preservation	M	M	M	G	G	M	M	G	M
Assipetra infracretacea	1	1	.	1	.	.	.	1	.
Axopodorhabdus dietzmannii	1	.	.	3	2	.	.	1	.
Biscutum constans	5	2	1	26	32	13	.	49	1
Cretarhabdus striatus	1	.	.	1	1	.	.	.	.
Cretarhabdus sp.	1	1	.	1	1	.	.	1	.
Crucibiscutum salebrosum	2	3	.	4	8	8	.	1	1
Cyclagelosphaera margerelii	21	8	2	12	10	6	4	82	6
Diazomatolithus lehmanii	1	1	.	7	16	3	.	20	.
Grantarhabdus meddii	1	.	.	1	1	1	.	.	.
Lithraphidites carniolensis	1	1	.	7	3	3	1	4	1
Micrantholithus obtusus	1	1	.	7	7	1	.	4	.
Rhagodiscus asper	1	.	.	3	2	.	.	5	1
Rotelapillus laffittei	1	1	.	1	5	1	.	1	.
Vekshinella stradneri ssp. 3	1	.	.	.	.	.	.	.	.
Watznaueria barnesae	89	83	9	179	159	232	15	126	23
Watznaueria ovata	1	1	.	6	.	1	.	.	1
Zygodiscus erectus	4	4	.	6	15	5	.	5	.
Cretarhabdus crenulatus	.	1	.	.	.	.	.	.	.
Vekshinella stradneri ssp. 1	.	1	.	6	2	2	1	1	.
Watznaueria britannica	.	1	.	9	19	3	.	6	.
Discorhabdus rotatorius	.	.	.	2	2	1	.	1	.
Cretarhabdus conicus	.	.	.	1	1	.	.	.	.
Corollithion geometricum	.	.	.	1	1	.	.	2	.
Hemipodorhabdus gorkae	.	.	.	1	1	.	.	.	.
Micrantholithus sp.	.	.	.	1	.	.	.	.	.
Nannoconus sp.	.	.	.	1	.	.	.	2	.
Sollasites horticus	.	.	.	4	4	.	.	5	.
Tegumentum striatum	.	.	.	5	14	7	.	10	1
Vekshinella quadriarculla	.	.	.	1	.	.	.	.	.
Zygodiscus diplogrammus	.	.	.	1	.	.	.	1	.
Micrantholithus hoschulzii	.	.	.	.	1	.	.	.	.
Microstaurus chiastius	.	.	.	.	1	.	.	.	.
Nannoconus globulus	.	.	.	.	.	.	.	1	.
Nannoconus kamptneri	.	.	.	.	.	.	.	1	.
Scapholithus fossilis	.	.	.	.	.	.	.	1	.
Tranolithus gabalus	.	.	.	.	.	.	.	1	.
Sample no.	95/1	95/2	97/1	97/2	99/1	99/2	99/3	101/1	103/1
% $CaCO_3$	2.5	2.9	1.5	7	6	3.9	1.2	8.3	3.5
Lithology									
Age	Late Valanginian								

Fig. 5: Distribution of nannofossils in the Hollwede section, NW Germany. Preservation: G = good, M = moderate. For the explanation of the lithology compare Fig. 3. The exact position of the samples and the lithology are given in MUTTERLOSE (1992b).

The species listed in Fig. 4 are typical Valanginian to earliest Hauterivian assemblages. Most common is *Watznaueria barnesae*, an environmentally tolerant and cosmopolitan species. In samples with more than 100 specimens the relative abundance of *W. barnesae* varies from 39% (sample 99/4) to 93% (sample 99/5). Other common species include *Biscutum constans*, *Cyclagelosphaera margerelii*, *Zygodiscus diplogrammus*, *Zygodiscus erectus*, *Diazomatolithus lehmanii*, *Lithraphidites carniolensis*, *Vekshinella stradneri* and *Rhagodiscus asper*. All these are cosmopolitan species, which are present throughout the Early Cretaceous.

Biostratigraphic important index species include *Speetonia colligata*, *Tegumentum striatum* and *Cruciellipsis cuvillieri*. *S. colligata* ranges from the Berriasian to the Hauterivian, *T. striatum* from the Late Valanginian to the Early Hauterivian. Rare specimens of *C. cuvillieri* (Berriasian to Late Hauterivian) have been observed in an additional sample (above bed 103), not listed in the range chart. All three species have been described from the Boreal Realm, the Tethys and the Indian Ocean.

Strictly Tethyan species are rare or absent: *Calcicalathina oblongata*, *Conusphaera mexicana* and *Tubodiscus* spp. have not been observed. The genus *Nannoconus*, abundant in coeval strata of the Tethyan Realm, is extremely rare. Species of Boreal affinities, however, do occur. *Crucibiscutum salebrosum* and *Micrantholithus speetonensis* are present in sample 99/1. *C. salebrosum*, abundant in the Late Valanginian to Early Hauterivian, is restricted to two high latitude belts; this species has not been described from the Tethys so far (MUTTERLOSE 1992c). It seems likely, that this species is a cold water morphotype. *M. speetonensis* has been documented only from the Valanginian of the North Sea and Speeton, NE England (PERCH-NIELSEN 1979). More precise biostratigraphic data are not available for the North Sea. In Speeton *M. speetonensis* is restricted to beds D4A and D4B, which are of Early Valanginian age (CRUX 1989). However, at Speeton only 5.5 m of Lower Valanginian clays are present and the Upper Valanginian is missing. According to the present data the range of *M. speetonensis* has to be extended at least into the early Late Valanginian. In conclusion, the nannofloras of the early Late Valanginian of the Wawal section have a Boreal character, Tethyan elements being largely absent.

5.2 HOLLWEDE (NW GERMANY)

All seven samples studied, yield a nannoflora of low diversity and low abundance (Fig. 5). The preservation is moderate, the calcium carbonate content varies from 1% to 8%. *Watznaueria barnesae* is again the dominant species. In samples with more than 100 specimens the relative abundance of *W. barnesae* varies from 60% (sample 97/2) to 82% (sample 95/2). *Cyclagelosphaera margerelii*, *Biscutum constans*, *Diazomatolithus lehmanii*, *Zygodiscus erectus*, *Micrantholithus obtusus*, *Crucibiscutum salebrosum*, *Watznaueria britannica*, *Tegumentum striatum* and *Vekshinella stradneri* are present throughout the sequence. Tethyan species are once again missing, a few specimens of *Nannoconus* spp. have been observed. Though *M. speetonensis* is missing, the assemblages show Boreal affinities.

5.3 TWIEHAUSEN (NW GERMANY)

About twenty samples from this section were studied, eight of these yield an extremely impoverished nannoflora (Fig. 6). The assemblages are of low abundance and low diversity, only seven species were observed. These assemblages correspond to a low calcium carbonate content of 1%. No Tethyan elements were observed.

TWIEHAUSEN																		
Age	Ammonite Zone	Sample no.	Fields of view	Number of species	Individuals	Preservation	*Rhagodiscus asper*	*Tegumentum striatum*	*Watznaueria barnesae*	*Watznaueria ovata*	*Diazomatolithus lehmanii*	*Cretarhabdus conicus*	*Lithraphidites carniolensis*	*Vekshinella stradneri*	Sample no.	% $CaCO_3$	Lithology	Age
Late Valanginian	*hollwedensis*	89/2	200	.	.	.	.	.	.	.	.	.	.	.	89/2	0.7		Late Valanginian
		89/1	200	.	.	.	.	.	.	.	.	.	.	.	89/1	0.7		
		85/4	200	5	43	M	15	.	25	.	.	1	1	1	85/4	0.8		
		85/3	200	.	.	.	.	.	.	.	.	.	.	.	85/3	0.8		
		85/2	53	2	2	P	.	.	1	.	1	.	.	.	85/2	0.7		
		85/1	200	.	.	.	.	.	.	.	.	.	.	.	85/1	0.8		
		83/1	200	1	5	M	.	.	5	.	.	.	.	.	83/1	0.8		
		81/1	200	4	5	M	1	1	2	1	.	.	.	.	81/1	1		

Fig. 6: Distribution of nannofossils in the Twiehausen section, NW Germany. Preservation: M = moderate, P = poor. For the explanation of the lithology compare figure 3. The exact position of the samples and the lithology are given in MUTTERLOSE (1992b).

6. PALAEOBIOGEOGRAPHY AND PROVINCIALISM

Calcareous nannofossils show a provincialism during the Berriasian-Barremian interval of the Early Cretaceous, similar to that exhibited by micro- and macrofaunas (foraminifera, ammonites, belemnites, bivalves, brachiopods). Based on calcareous nannofossils two different floral realms, the Tethys and the Boreal Realm can be recognized. Each of these realms is characterized by different species (MUTTERLOSE 1992c). Tethyan and cosmopolitan species are present in the Tethys, while the Boreal Realm is marked by Boreal, cosmopolitan and Tethyan taxa.

Tethyan species include *Diadorhombus rectus*, *Rucinolithus wisei*, *Conusphaera* spp., *Nannoconus* spp. (except for *N. abundans* and *N. borealis*), *Lithraphidites bollii*, *Calcicalathina oblongata*, *Cruciellipsis cuvillieri*, *Tubodiscus* spp. These spread out only under suitable ecological conditions into other areas. It seems likely that temperature, sea level changes and the presence of suitable seaways were the main factors controlling the palaeobiogeographic distribution of this group.

Conversely, boreal species include *Sollasites horticus*, *Corollithion silvaradion*, *Kokia* spp., *Sollasites arcuatus*, *Eprolithus antiquus*, *Perissocyclus fletcheri*, *Tegulalithus septentrionalis* and *Micrantholithus speetonensis*. These species are restricted to the Boreal Realm.

Berriasian sediments throughout NW Europe are characterized by a dominance of non-marine strata, reflecting widespread regression. Faunas and floras preserved in rare marine incursions are of purely Boreal provenance, showing close links to those of the Russian Platform (MUTTERLOSE 1992a). The subsequent Valanginian stage is marked by major palaeoceanographic changes. The earliest Valanginian is characterized by a major transgression and the return of marine conditions over wide areas of NW Europe. In the course of this transgression the Carpathian seaway opened via Poland, allowing an exchange of Boreal and Tethyan floras and faunas. This marine seaway between the Tethyan and Boreal Realms existed throughout the Valanginian (Fig. 7). A further transgression in the early Late Valanginian (*Prodichotomites hollwedensis* zone) expanded this seaway further. Possible shifts in the provenance of the marine floras and faunas in Poland should thus reflect sea level changes. Palaeoclimatic variation may also have influenced provenance: this has yet to be documented in the same detail as sea level changes.

The ammonite fauna of the Wawal section has been described recently in detail by KUTEK et al. (1989). The Lower Valanginian yields rich Tethyan assemblages (*Karakaschiceras* spp.), associated with Boreal (?)*Platylenticeras*. In the basal part of the subsequent Upper Valanginian (the *Prodichotomites hollwedensis* zone) Tethyan ammonites (*Saynoceras*, *Valanginites*, *Olcostephanus*, *Neocomites*, *Karakaschiceras*, *Bochianites*) are found in the same strata as the Boreal ammonite genus *Prodichotomites*. This horizon corresponds to the early Late Valanginian transgression, which is evident over much of Europe: in NW Germany the transgression caused expansion of the Lower Saxony Basin. The early Late Valanginian *Prodichotomites hollwedensis* ammonite zone shows strong influxes of Tethyan ammonites: a first immigration wave of

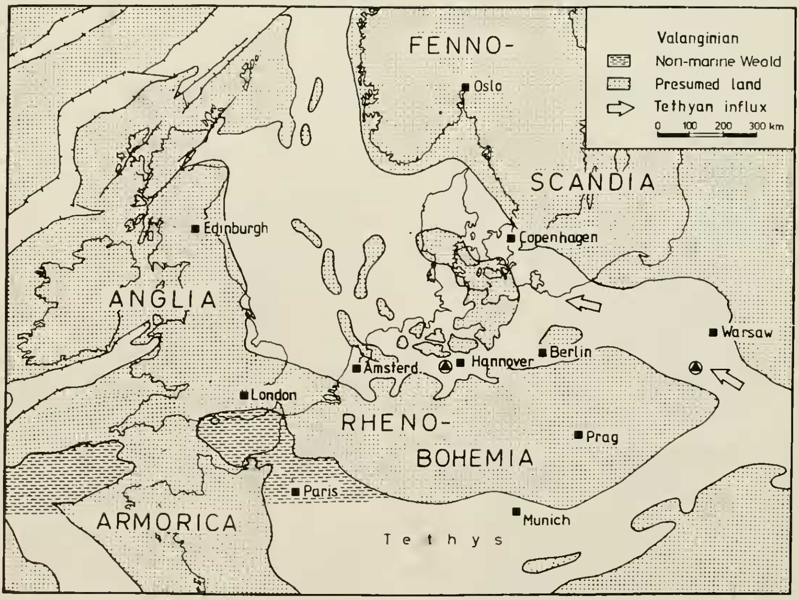


Fig. 7: Palaeogeographic map for the Valanginian of NW Europe. After MUTTERLOSE (1992a).

large sized *Olcostephanus* is followed by a main influx of *Valanginites*, *Bochianites*, *Saynoceras*, *Neohoploceras* and *Karakaschiceras* (KEMPER et al. 1981, MUTTERLOSE 1992a). The subsequent *Dichotomites* beds are dominated in the Wawal section and in NW Germany by the Boreal ammonite genera *Prodichotomites* and *Dichotomites*.

The nannofossil assemblages of both the *P. hollwedensis* zone and the subsequent *Dichotomites* beds in the Wawal section are of clearly Boreal affinities. Tethyan genera are extremly rare or absent in the *P. hollwedensis* zone. The absence of Tethyan nannofloras in beds with strong influxes of Tethyan ammonites may be explained by the following possibilities:

1. Poor preservation causing the absence of Tethyan nannofossils.
2. Water depth restricting the Tethyan elements to shallow or deep-water settings.
3. Facies control excluding Tethyan nannofossils from the Boreal siliciclastic facies.
4. Nannofossils are ecologically more sensitive than ammonites, restricting the spread of warm-water Tethyan species into the Boreal Realm.

Preservational factors can be excluded for two reasons. Though preservation in general is moderate, the samples with Boreal assemblages do not show evidence of dissolution. Furthermore Tethyan nannoconids, *Conusphaera* spp. and *C. oblongata* are more prone to solution or are solution resitant, due to their wall structure (e. g. THIERSTEIN 1976). Water depth may control the distribution of nannofossils, limiting Tethyan species to shallow or deep water settings. However, *Nannoconus*-rich assemblages have been described from Early Cretaceous sediments of Central Italy, also in sections of palaeodepth up to 1000–2000 m (ARTHUR & PREMOLI-SILVA 1982).

BUSSON & NOEL (1991) suggested that nannoconids preferred clean, clear water, being abundant in limestone and absent or rare in siliclastic layers. This facies control could explain the absence of nannoconids in the siliciclastics of Poland and NW Germany. This fails to explain the absence of the other Tethyan taxa, which are typical in siliciclastic facies. Furthermore, no nannoconids have been observed in the Early Hauterivian „reef facies" of the eastern part of NW Germany. This facies consists of shallow water limestones with strong influxes of stenothermal benthic warm water faunas (foraminifera, algae, sponges, corals, bryozoans; MUTTERLOSE 1992a).

A further possibility is that the distribution of calcareous nannofossils is more strongly controlled by climatic factors than in other groups. The evidence for this is outlined below. Strong geological and palaeontological evidence suggest a major transgression for the early Late Valanginian *Prodichotomites hollwedensis* zone. This transgression obviously enabled Boreal nannofossils (*M. speetonensis*, *C. salebrosum*) and ammonites to spread south. Both species have been mentioned from the Valanginian of the southern Carpathians (Romania), where they are associated with Boreal ammonites (MELINTE 1991). Despite the presence of suitable seaways, Tethyan species were not able to make their way to Poland and NW Germany, suggesting these nannofloras to be sensitive to climatic variation.

In the Tethys extremely common in limestones, nannoconids show a slightly different distribution to that of coccoliths. In the Valanginian of the Boreal Realm they are generally rare. They have only been described from the early Late Valanginian (*Prodichotomites hollwedensis* zone) of NW Germany. This short influx of Tethyan nannoconids which is coeval with the influx of Tethyan ammonites in the earliest Late Valanginian, marks a particular immigration horizon (*Nannoconus* spp. A horizon, MUTTERLOSE 1991, 1992c). The rarity of nannoconids in the early Late Valanginian of the Wawal section, which is intermittent in between the Tethys and the Boreal Realm, is surprising. However, nannoconids are always rare in the NW German sections making up to 2% of the assemblage. The rarity of nannoconids in Poland may be explained by the factors quoted above (restricted to deep or shallow settings; facies control; climatic control). Alternatively nannoconids might have used a different migration route (e. g. a shallow sea-way via the Proto Atlantik) to invade the North Sea basin. Presently there are not enough data available to come to final conclusions.

7. CONCLUSIONS

The provenance of marine floras and faunas observed in the early Late Valanginian of Central Poland are somehow contradictory. Boreal ammonite populations remained stable even during strong Tethyan influxes. The calcareous nannofossils are, however, of purely Boreal affinities; Tethyan elements being largely absent. The nannofossil assemblages clearly support the idea of a widespread transgression in the *Prodichotomites hollwedensis* ammonite zone, allowing Boreal species to migrate towards the south. The absence of Tethyan species making their way north via the Polish basins suggests that calcareous nannofossils are extremely sensitive to climatic variations that presumably existed between the Boreal and Tethyan Realms.

8. APPENDIX

List of calcareous nannofossils in alphabetical order of generic epithets:

Assipetra infracretacea (THIERSTEIN, 1973) ROTH, 1973
Axopodorhabdus dietzmannii (REINHARDT, 1965) WIND & WISE, 1977
Biscutum constans (GORKA, 1957) BLACK, 1967
Calcicalathina oblongata (WORSLEY, 1971) THIERSTEIN, 1971
Conusphaera TREJO, 1969
Conusphaera mexicana TREJO, 1969
Corollithion geometricum (GORKA, 1957) MANIVIT, 1971
Corollithion silvaradion FILEWICZ et al. in WISE & WIND, 1977
Cretarhabdus BRAMLETTE & MARTINI, 1964
Cretarhabdus angustiforatus (BLACK, 1971) BUKRY, 1973
Cretarhabdus conicus BRAMLETTE & MARTINI, 1964
Cretarhabdus crenulatus BRAMLETTE & MARTINI, 1964
Cretarhabdus striatus (STRADNER, 1963) BLACK, 1973
Crucibiscutum salebrosum (BLACK, 1971) JAKUBOWSKI, 1986
Cruciellipsis cuvillieri (MANIVIT, 1966) THIERSTEIN, 1971
Cyclagelosphaera margerelii NOËL, 1965
Diadorhombus rectus WORSLEY, 1971
Diazomatolithus lehmanii NOEL, 1965
Discorhabdus rotatorius (BUKRY, 1969) THIERSTEIN, 1973
Eprolithus antiquus PERCH-NIELSEN, 1979
Grantarhabdus meddii BLACK, 1971
Hemipodorhabdus gorkae (REINHARDT, 1969) GRUN in GRUN & ALLEMANN, 1975
Kokia PERCH-NIELSEN, 1988
Lithraphidites bollii (THIERSTEIN, 1971) THIERSTEIN, 1973
Lithraphidites carniolensis DEFLANDRE, 1963
Manivitella pemmatoidea (DEFLANDRE in MANIVIT, 1965) THIERSTEIN, 1971
Micrantholithus hoschulzii (REINHARDT, 1966) THIERSTEIN, 1971
Micrantholithus obtusus STRADNER, 1963
Micrantholithus speetonensis PERCH-NIELSEN, 1979
Microstaurus chiastius (WORSLEY, 1971) GRUN in GRÜN & ALLEMANN, 1975
Nannoconus KAMPTNER, 1931
Nannoconus abundans STRADNER & GRUN, 1973
Nannoconus borealis PERCH-NIELSEN, 1979
Nannoconus elongatus BRÖNNIMANN, 1955
Nannoconuc globulus BRÖNNIMANN, 1955
Nannoconus kamptneri BRONNIMANN, 1955
Perissocyclus fletcheri BLACK, 1971
Rhagodiscus asper (STRADNER, 1963) REINHARDT, 1967
Rotellapillus laffittei (NOËL, 1957) NOËL, 1973
Rucinolithus wisei THIERSTEIN, 1971
Scapholithus fossilis DEFLANDRE in DEFLANDRE & FERT, 1954
Sollasites arcuatus BLACK, 1971
Sollasites horticus (STRADNER et al. in STRADNER & ADAMIKER, 1966) CEPEK & HAY, 1969
Speetonia colligata BLACK, 1971
Tegulalithus septentrionalis (STRADNER, 1963) CRUX, 1986
Tegumentum striatum (BLACK, 1971) TAYLOR, 1978
Tranolithus gabalus STOVER, 1966
Tubodiscus THIERSTEIN, 1973
Vekshinella quadriarculla (NOËL, 1965) ROOD et al., 1971
Vekshinella stradneri ROOD et al., 1971
Watznaueria barnesae (BLACK in BLACK & BARNES, 1959) PERCH-NIELSEN, 1968
Watznaueria britannica (STRADNER, 1963) REINHARDT, 1964
Watznaueria ovata BUKRY, 1969
Zygodiscus diplogrammus (DEFLANDRE in DEFLANDRE & FERT, 1954) BRAMLETTE & MARTINI, 1964
Zygodiscus erectus (DEFLANDRE in DEFLANDRE & FERT, 1954) REINHARDT, 1965

List of ammonites in alphabetical order of generic epithets:

Bochianites LORY, 1898
Dichotomites KOENEN, 1909
Karakaschiceras THIEULOY, 1971
Neocomites UHLIG, 1905
Neohoploceras SPATH, 1939
Olcostephanus NEUMAYR, 1875
Platylenticeras HYATT, 1900
Polyptychites PAVLOW, 1892
Prodichotomites KEMPER, 1971
Saynoceras MUNIER-CHALMAS, 1893
Valanginites KILIAN, 1910

Plate 1 — Photomicrographs from the early Late Valanginian *Prodichotomites hollwedensis* ammonite zone. All figures 3080x. The slides are deposited with the Bayerische Staatssammlung für Paläontologie und historische Geologie, München

Fig. 1–6 — *Crucibiscutum salebrosum* (BLACK, 1971) JAKUBOWSKI, 1986. – (1, 3, 4, 5, 6) POL; (2) TL; (1, 2) Sample Hollwede 101/1/90; (3) Sample Hollwede 99/2/90; (4, 5) Sample Hollwede 103/1/90; (6) Sample Hollwede 99/1/90. Boreal species.

Fig. 7, 8 — *Biscutum constans* (GORKA, 1957) BLACK, 1967. – (7) POL; (8) TL; Sample Hollwede 101/1/90.

Fig. 9–11 — *Tegumentum striatum* (BLACK, 1971) TAYLOR, 1978. – POL; Sample Hollwede 97/2/90.

Fig. 12 — *Diazomatolithus lehmanii* NOEL, 1965. – POL; Sample Hollwede 101/1/90.

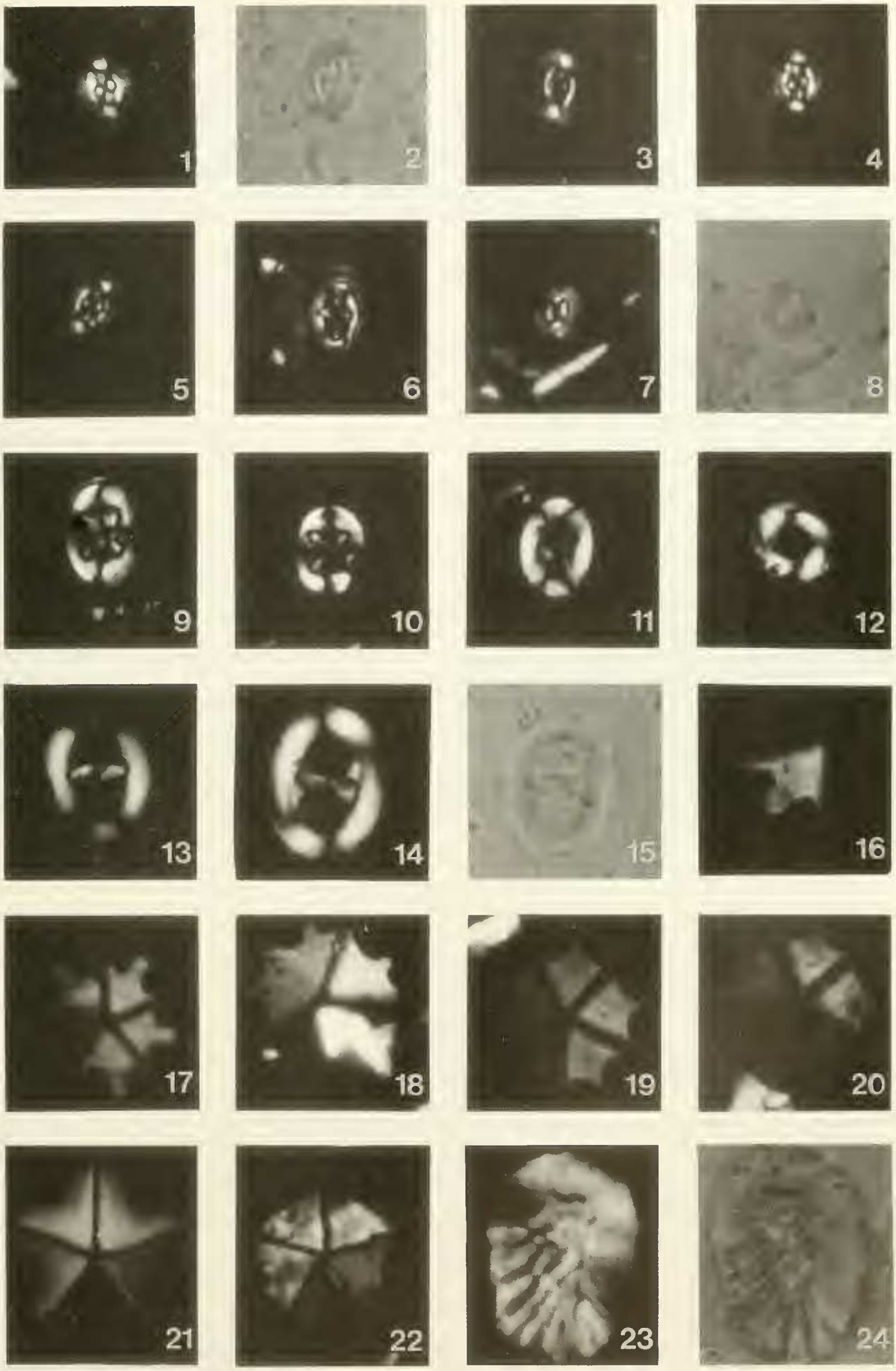
Fig. 13–15 — *Speetonia colligata* BLACK, 1971. – (13, 14) POL; (15) TL; Sample Wawal 99/1/91.

Fig. 16–20 — *Micrantholithus speetonensis* PERCH-NIELSEN, 1979. – POL; Sample Wawal 99/1/91. Boreal species.

Fig. 21 — *Micrantholithus obtusus* STRADNER, 1963. – POL; Sample Hollwede 97/2/90.

Fig. 22 — *Micrantholithus hoschulzii* (REINHARDT, 1966) THIERSTEIN, 1971. – POL; Sample Wawal 99/1/91.

Fig. 23, 24 — *Nannoconus kamptneri* BRÖNNIMANN, 1955. – (23) POL; (24) TL; Sample Hollwede 101/1/90.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

REFERENCES

Arthur, M. A. & Premoli-Silva, I. (1982): Development of widespread organic carbon-rich Strata in the Mediterranean Tethys. – In: Schlanger, S. O. & Cita, M. B. (Eds.), Nature and origin of Cretaceous carbon-rich facies, 7-54; London (Academic Press).

Bartenstein, H. & Bettenstaedt, F. (1962): Marine Unterkreide (Boreal und Tethys). – In: Arbeitskreis deutscher Mikropaläontologen (Ed.), Leitfossilien der Mikropaläontologie, 225–297, figs. 17–24, tab. 17–18, pl. 33–41; Berlin.

Busson, G. & Noel, D. (1991): Les nannoconidés, indicateurs environnementaux des océans et mers épicontinentales du Jurassique terminal et du Crétacé inférieur. – Oceanologica Acta, 14 (4): 333–356, 14 figs.; Paris.

Crux, J. A. (1989): Biostratigraphy and palaeogeographical applications of Lower Cretaceous nannofossils from north western Europe. – In: Crux, J. A. & van Heck, S. (Eds.), Nannofossils and their applications, 143–211, 14 figs., 14 pls.; Chichester.

Kemper, E. (1978): Einige neue biostratigraphisch bedeutsame Arten der Ammoniten-Gattung *Dichotomites* (NW-Deutschland, Obervalangin). – Geol. Jb., A 45: 183–253, 18 figs., 16 pls.; Hannover.

Kemper, E., Rawson, P. F. & Thieuloy, J.-P. (1981): Ammonites of tethyan ancestry in the early Lower Cretaceous of north-west Europe. – Palaeontology, 24: 251–311, 8 figs., 13 pls.; London.

Kutek, J., Marcinowski, R. & Wiedmann, J. (1989): The Wawal Section, Central Poland – An important link between boreal and tethyan Valanginian. – In: Wiedmann, J. (Ed.), Cretaceous of the Western Tethys. Proc. 3rd Int. Cretaceous Symp., 717–754, 6 figs., 2 tabs., 2 pls.; Stuttgart (Schweizerbart).

Marek, S. (1983): Epikontinentale Unterkreide-Ablagerungen in Polen. – Zitteliana, 10: 55–64, 5 figs., 1 tab.; München.

Marek, S. & Raczynska, A. (1979): Paläogeographie der Unterkreide des nordpolnischen Beckens. – In: Wiedmann, J. (Ed.), Aspekte der Kreide Europas. IUGS Series, A 6: 447–462, 4 figs., 2 tab.; Stuttgart.

Melinte, M. (1991): Late Jurassic – Early Cretaceous calcareous nannoplankton biostratigraphy from southern Carpathians (Romania). – INA Newsletter, 13 (2): 57; London.

Mutterlose, J. (1990): A belemnite scale for the Lower Cretaceous. – Cretaceous Research, 11: 1–15, 8 figs.; London.

Mutterlose, J. (1991): Das Verteilungs- und Migrationsmuster des kalkigen Nannoplanktons in der borealen Unterkreide (Valangin-Apt) NW-Deutschlands. – Palaeontographica, B 221: 27–152, 43 figs., 17 pls.; Stuttgart.

Mutterlose, J. (1992a): Migration and evolution patterns of floras and faunas in marine Early Cretaceous sediments of N-W-Europe. – Palaeogeogr., Palaeoclimatol., Palaeoecol., 94: 261–282, 8 figs.; Amsterdam.

Mutterlose, J. (1992b): Die Unterkreide-Aufschlüsse (Berrias-Hauterive) im nördlichen Wiehengebirgsvorland (N-Deutschland). – Geol. Paläont. Westf., 21: 39–113, 19 figs., 14 pls.; Münster.

Mutterlose, J. (1992c): Biostratigraphy and palaeobiogeography of Early Cretaceous calcareous nannofossils. – Cretaceous Research, 13: 167–189, 9 figs.; London.

Perch-Nielsen, K. (1979): Calcareous nannofossils from the Cretaceous between the North Sea and the Mediterranean. – In: Wiedmann, J. (Ed.), Aspekte der Kreide Europas. IUGS Series, A 6: 223–272, 2 pls.; Stuttgart (Schweizerbart).

Perch-Nielsen, K. (1985): Mesozoic calcareous nannofossils. – In: Bolli, H. M., Saunders, J. B. & Perch-Nielsen, K. (Eds.), Plankton Stratigraphy, Cambridge earth science series, 329–426, 92 figs.; Cambridge.

Raczynska, A. (1979): The stratigraphy and lithofacies development of the younger Lower Cretaceous in the Polish Lowlands. – Prace Inst. Geol., 89: 78 pp., 27 figs., 4 pls.; Warszawa.

Rawson, P. F. (1983): The Valanginian to Aptian stages - current definitions and outstanding problems. – Zitteliana, 10: 493–500, 3 tabs.; München.

Rawson, P. F., Curry, D., Dilley, F. C., Hancock, J. M., Kennedy, W. J., Neale, J. W., Wood, C. J. & Worssam, B. C. (1978): A correlation of Cretaceous rocks in the British Isles. – Geol. Soc. London, Spec. Rep., 9: 70 pp., 6 figs.; London.

Thierstein, H. R. (1976): Mesozoic calcareous nannoplankton biostratigraphy of marine sediments. – Marine Micropaleontology, 1: 325–362, 8 figs., 5 pls.; Amsterdam.